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CREATIVITY IN SCIENCE AND TECHNOLOGY

Psychological Study

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The solution of problems concerned with creativity not only provide theoretical insights but also open way for wide applications in various spheres of social practice, particularly research and development, management and control, education, search for talents, etc.

In a series of psychological studies published in recent years, partly as a teamwork, the author has analysed the characteristics, conditions and forms of creative activities in science and technology. His studies, involving about 300 workers, have been carried out in four research institutes of chemical and textile industries and a technical planning and designing institute of communication engineering.

Resolving his project, intended after all to clear up conditions and prerequisites of creative work in the above institutions, the author has applied the method of complex inquiry to find the specific aspects and peculiarities of the various work activities (tasks) performed by different categories of personnel in different types of institutions. In addition to the analysis and classification of the tasks, he has given special attention to creative thinking and intelligence, interests and motivation as well as personality of the workers. Another important consideration has been the qualification, organization and social factors. The results of the psychological investigation have been confronted with subjective successfulness criteria of three independent judges and objective productivity criteria for research workers (publications, patents, research reports).

The present study summarizes main results of the mentioned research programme as well as the theoretical and methodological premises. Its objective is:

1. to pass a critical review of and analyze the actual psychology of creative activity in science and technology with regard to the process of solving the problems, the structure of psychical activity and personality, the role of environment, results and products of activity;
2. to attempt to elaborate a broad psychological conception of creative activity keeping in line with the theoretical and methodological views of Marxist philosophy and psychology, the principle of reflection and the general theory of activity;
3. to define, on the basis of the author's empirical data, the basic structures of activity as encountered in the research institutions and the planning and designing institute, to establish their psychological and qualification components, to specify the relations existing between the components of the whole system, particularly as far as they are relevant factors for productivity and efficiency of work;
4. to analyse in detail the conditions influencing the job satisfaction and to clear up the relationship between satisfaction and productivity or fluctuation of workers.

Theoretical Premises

The first chapter is a survey of the definitions of creativity as given by the main theories of psychology. The second chapter deals with the analysis of the creativity process and the organization used to solve problems. The third chapter is devoted to the psychical structure of creative activity. The fourth chapter is a study of the relation between personality and creativity. The fifth chapter establishes the effect of environment on creativity whereas the concluding sixth chapter serves to discuss the products and criteria of creative activity.

In empirical researches, creativity is usually defined in terms of products or processes of creativity. These views are, as a rule, completed by inquiries into the creator's personality and the environment in which creativity takes place.

Integration of research data in this respect is desirable and even urgent. It implies, on the one hand, incorporation in the general theory of human cognition and practice and, on the other hand, elaboration of new methodological approaches and interpretation principles, with interdisciplinary connections being respected.

Marxist psychology has provided some significant concepts applicable to the problems

of creativity, such as the principle of reflection, the principle of activity, the principle of socio-historical determination and evolution of psychical phenomena and the principle of personality.

Creative activity is understood to be a specific process of interaction between the individual or group of individuals and the material and social world, a process which provides new and original solutions of problems and brings new scientific and technical discoveries, new methods, products and social values. Conditioned in a complex way, creativity develops in dialectic unity of objective and subjective factors (with the subject playing an active part). It is based on the actual state of social knowledge and practice and extends it. The main source of human creativity is the objective social need and the necessity to solve pending and complex problems presented by life, production, science, technology and culture.

Being an organized process of transformation of knowledge and reality, man's creative activity is subject to numerous psychological factors and laws.

In terms of the theory of activity as developed by Marxist psychology, every structure of activity can be considered as linked up with definite cognitive, motivating and executive structures which enable to fulfill given tasks. The results must take a communicable form to allow social utilization.

The fundamental relations relevant for any solution of psychological problems are those existing between the conditions, goals, means, criteria of activity, on the one hand, and the results or products, on the other hand.

Creative thinking and activity have to be judged by the way they go to extend the social understanding and control of the world. The creativity criteria to be applied cannot be derived only conceptually; they should be based on facts borne out by the objective scientific analysis and social practice. Psychological and physiological criteria alone (e.g. originality of thoughts, rare and unusual answers, fluency and flexibility of ideas, new connections, etc.) appear to be insufficient.

The phenomena of creativity being multilaterally conditioned, their research demands a system approach to be completed by other methods used to study human activity, in particular the structural and comparative analysis, the functional analysis, the differential and development method, the method of experiment and model, etc.

Some New Research Data

The psychological analysis of research work revealed a great variety of activities and tasks in the different types of institutions and working categories under consideration. Thus **creative and routine** activities have to be differentiated. Another important category was the **managing activity**. Besides, the creative workers were engaged in the **basic and the applied research**.

The author analysed conditions which influence the times required by the different categories of activities and tasks (scientific degrees, function, education, assignment, etc.).

In addition, he established correlations between various tasks on the one hand, and the results of the psychological investigation (creativity test by Guilford, Jäger, intelligence test, years of service, job satisfaction, etc.) on the other hand. The tasks correlating positively with the indicators of creative thinking, such as coordination of research team and preparation of publications, gave positive correlations with the production criteria as well. Yet the range of specialized technical tasks, which was in negative correlation with the indicators of creative thinking, correlated in a similar way also with the production criteria. The level of general intelligence indicated a faint positive correlation especially with the range of specialized technical tasks, but its correlations with the coordination of research team and the preparation of publications was negative. Creative tasks correlated also positively with job satisfaction whereas the routine activities and the specialized technical tasks had a negative correlation. Particular tasks provided differing correlations with the years of service.

In analysing the workers of the technical planning and designing centre, the author envisaged also the material contents of the work activity and defined the psychological, social and qualification requirements. The staff was classified in 29 categories depending on age, sex, education, years of service, function and assignment. In accordance with the comparative and correlation analysis the work activities were classified as follows: 1 – creative technical planning activities (projects); 2 – managing activity (in the planning

centre); 3 – technical planning activities; 4 – technical calculation activities; 5 – designer's activities; 6 – draughtman's activities.

The nature of the material to be handled appeared to be an important differentiating feature for particular working categories. For example, the architects were primarily concerned with three-dimensional, figural and coloured materials; the management workers had to do with people and verbal material; the calculators handled mostly numerical material whereas the designers and draughtmen were busy with building and construction materials.

The work with three-dimensional and figural materials correlated well also with the range of creative activities.

Much the same as research workers, the category of creative planning personnel concerned with projects pursued heuristic values, the management personnel was engaged in controlling work of the other employees whereas the prevailing factors for the bottom categories were those of variation, efficiency and the so-called hygienic environment factors.

In accordance with other authors, the present study has proved that general intelligence shows no demonstrable relation with creativity of research workers. Dependence on education and age of workers, the intelligence score does not set off, in terms of publications, patents and research reports, the most productive categories of the basic and applied research workers. It does not differentiate workers with scientific and those with technical qualifications, either. On the contrary, higher scores were achieved by the routine workers.

A set of eight tests of creative thinking goes to show that the maximum scores were reached by senior workers of basic and applied research. Similar results have been registered also for the leading research workers and the department chiefs without scientific degrees. The lower working categories have showed low scores in the tests of creative thinking. The basic research workers have attained best results in Sargent's Insight Test, designed to reveal causes which lead to a definite behaviour. The other tests, however, have generally given better results for the applied research workers.

Based on the analysis of the methods used, the author has inferred a hypothesis that the typical feature of basic research workers is the search for new causal relations between experience data whereas the applied research workers are more characterized by the ability of discovering functional relations inherent in systems and relations between means and the goal. It appears that quite a number of creativity tests in use require a new psychological interpretation and that the role of relations has not yet found an adequate repercussion in the theory.

Most of the creativity tests have positively correlated with the range of production as regards publications, patents and research reports whereas the intelligence score have indicated minor negative correlations. This agrees with the analysis of the working activities and tasks.

In addition to creative thinking, it is the motivation to heuristic (inventive) activity that plays an important part. It gives positive relation to the production data. The creatively thinking and heuristically motivated senior research workers produced much more publications, patents than the other working categories. Those of the creative and motivated workers who had achieved scientific degrees and were engaged in the basic research have taken the lead as to publications. This lead does not apply to patents and research reports.

Not correlating appreciably with intelligence or creative thought, the lecturing interests, too, indicated positive relations to productivity in research, particularly as regards publications.

While the scientific qualification (scientific degree) influenced production in the sphere of publications, the technical qualification and the leading function in research were relevant factors for production in the field of patents and research reports. Of importance for the patent activity was the financial incentive, too. The years of service indicated a positive relation with productivity.

The total job satisfaction score was in no demonstrable relationship with productivity. Only the discontent with profession is likely to affect productivity. The dissatisfaction of research workers came out as a tendency of fluctuating within the framework of the institute or as efforts to leave the job altogether. The main source of the dissatisfaction were shortcomings in the management of the research institution.

In contrast to other studies, the author has not found any consistent relations between personality and productivity of the research workers. The tests of creative thinking corre-

lated positively with the scale of emotional stability (C), the scale H, and negatively with the scale L in the Cattell's questionnaire 16 P. F. Yet the scales did not differentiate the groups of highest qualifications and did not correlate with production data. On the other hand, correlations were found with subjective appreciation of successfulness of research workers. No relationship was revealed between the subjective appreciation of successfulness and the objective production criteria.

It follows from the foregoing that science and technology are likely to involve quite a number of creative activities depending on the nature of problems and tasks to be solved, job, material to work, working qualifications and fitness, personal interests and motivation of the worker, organization, and other factors. For different work functions creative thinking may come to play a more or less important role.

The conclusion of the study sketches some future trends in psychological investigations.